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Upgrading Foundry Wastewater Treatment

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UPGRADING FOUNDRY WASTEWATER TREATMENT

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16. ABSTRACT

The paper summarizes findings of a 10-week pilot plant study of gray iron foundry wastewater treatment. Treatment technologies studied included lime softening, lime/soda ash softening, polymer addition, flocculation/sedimentation, and dual media filtration. Results indicate that clarification with lime and polymer, followed by dual media filtration, provides effective treatment for discharge or potential reuse. Full scale costs and space requirements are included.

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Pollution	Sodium Carbonates	Pollution Control	13B
Waste Water	Polymers	Stationary Sources	07D
Waste Treatment	Flocculating	Dual Media Filtration	07A, 13H
Foundries	Sedimentation		13I 14G
Gray Iron	Filtration		11F
Calcium Oxides			07B

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INTRODUCTION

There are approximately 1600 ferrous foundries located through the United States. Approximately half operate manufacturing processes which result in process wastewater estimated at 4.0×10^8 m^3 (106×10^9 gallons) each year. Seventy-five percent of this wastewater is recycled, with the remainder being discharged to either navigable waters (23 percent) or publicly owned treatment works (POTW) (2 percent) (1).

Primary wastewater generating operations in the ferrous foundry industry include:

1. Dust Collection - 2.0×10^8 m^3/yr (52.8×10^9 gal/yr)
2. Melting Furnace Scrubber - 1.2×10^8 m^3/yr (31.4×10^9 gal/yr)
3. Slag Quenching - 0.43×10^8 m^3/yr (11.4×10^9 gal/yr)
4. Casting Quench and Mold Cooling - 0.18×10^8 m^3/yr (4.87×10^9 gal/yr)
5. Sand Washing - 0.09×10^8 m^3/yr (2.61×10^9 gal/yr)

The objective of this project was to determine the quality of treated iron foundry wastewater that could be achieved using chemical clarification and filtration technology. The project did not include evaluation of the technical feasibility of reusing wastewater of the quality produced by the pilot treatment system. The research work was performed at a large gray iron foundry with an average daily gross melt of 667 Mg (734 tons) and a wastewater flow of 8607 m^3/day (2.27 mgd). The typical water application rate during the 6 week investigation was 13 m^3 of wastewater per 1000 kg of gross melt (3105 gal/ton).

The study was performed on a pilot scale using the U.S. Environmental Protection Agency's (EPA's) mobile physical/chemical treatment system. This pilot plant is housed in a semi-trailer van as shown in Figure 1. Treatment processes evaluated during the study included lime softening, lime/soda ash softening, flocculation/sedimentation, and dual media filtration. The process treatment train schematic is illustrated in Figure 2.

PROJECT RESULTS

Raw Wastewater

Plant wastewater discharged to the receiving stream during the production week averaged 454 l/min (120 gal/min). The amount of water recycled during the production week averaged 92.2 percent of the incoming wastewater and ranged from 85 to 95.9 percent.

A summary of raw wastewater quality is shown in Table 1. Dissolved solids average 535 mg/l. Principal cations of interest included lead (59 mg/l), zinc (72 mg/l), calcium (60 mg/l), and aluminum (60.3 mg/l). The foundry

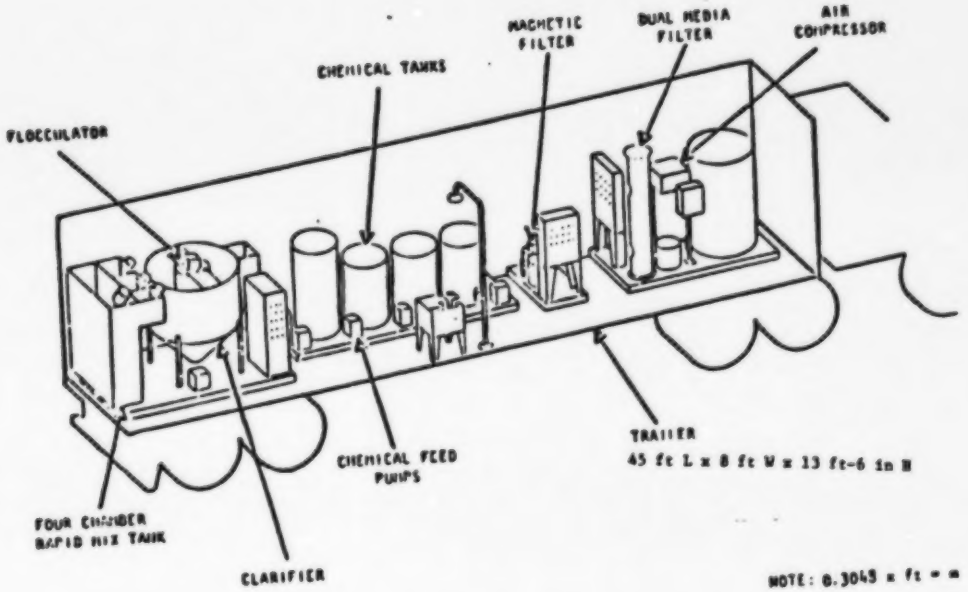

Figure 1. Mobile wastewater treatment system.

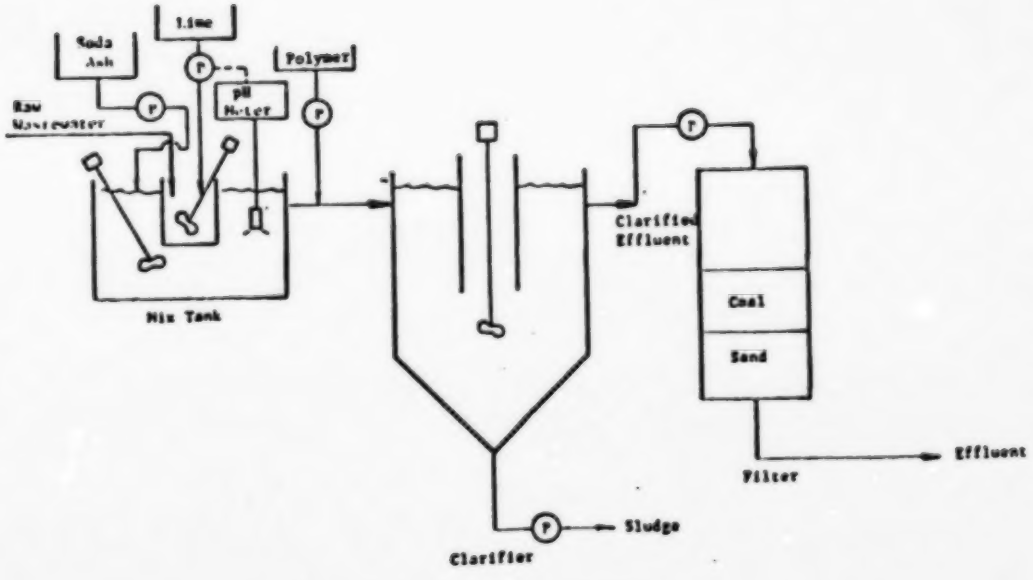

Figure 2. Pilot treatment trains investigated.

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wastewater also contained substantial concentrations of suspended solids (640 mg/l) and COD (315 mg/l).

TABLE 1. PRODUCTION WASTEWATER ANALYTICAL DATA SUMMARY

Parameter[a]	Average	Range
pH, units		5.65 - 6.78
Conductivity, umhos/cm	640 (11)[b]	580 - 800
Turbidity, NTU	125 (12)	63 - 220
Total alkalinity as $CaCO_3$	61 (14)	4 - 250
Total hardness as $CaCO_3$	93 (9)	67 - 125
Calcium hardness as $CaCO_3$	66 (8)	35 - 98
Suspended solids	640 (17)	314 - 1255
Dissolved solids	535 (14)	470 - 654
Chemical oxygen demand	315 (14)	112 - 860
Total organic carbon	55 (14)	33 - 72
Ammonia as N	5.18 (3)	3.80 - 7.50
Total cyanide	0.05 (2)	0.05
Sulfide	1 (2)	1
Color, APHA units	13 (1)	10 - 15
Total phosphorus as P	0.56 (7)	0.34 - 0.78
Lead	59 (17)	29 - 170
Zinc	72 (17)	36 - 162
Iron	47 (12)	18 - 76
Calcium	60 (15)	42 - 130
Sodium	81 (6)	58 - 100
Manganese	13.9 (6)	11.7 - 15.9
Magnesium	5.9 (15)	0.61 - 10.8
Aluminum	60.3 (6)	16.2 - 110
Cadmium	0.45 (5)	0.16 - 0.95
Silica	40 (3)	33 - 52
Sulfate	88 (6)	75 - 95
Chloride	65 (6)	54 - 77
Flow	5,820 l/min (1540 gal/min)	

[a]All units are mg/l unless stated otherwise.
[b]( ) indicates the number of data points used to obtain average.

Chemical Clarification

Chemical clarification was evaluated to determine its efficiency in reducing contaminants such as suspended solids, turbidity, and heavy metals in the raw wastewater. Testing was conducted using lime/polymer and lime/soda ash/polymer. Acid was investigated for neutralizing the clarified effluent. Treatment consisted of elevating the pH of the incoming wastewater to 10.0-10.5 with lime addition or lime plus soda ash. Polymer was used as a coagulant aid. The wastewater was settled in a flocculator clarifier, typically operating at an overflow rate of 52 $m^3/day/m^2$ (1272 gpd/ft^2). The clarified effluent was neutralized with sulfuric acid prior to filtering to eliminate potential scaling problems.

A summary of the pilot flocculator clarifier performance during the test program is presented in Table 2. These performance data were based on composite samples collected from the influent and effluent of the chemical clarification system. The data obtained during the study indicated that the pilot scale clarifier was capable of reducing influent suspended solids by about 95 percent. Suspended solids removal was found to be independent of overflow rate. Successful treatment was achieved at all overflow rates investigated, 25-62 $m^3/day/m^2$ (611-1526 gpd/ft^2). Settling rate was consistently about 0.15 m/min (0.5 ft/min). About 50 l of sludge was produced for each 1000 l of wastewater treated. The settled sludge could be further thickened to a maximum concentration of 100,000 mg/l using gravity thickening.

TABLE 2. CHEMICAL CLARIFICATION SYSTEM PERFORMANCE

Parameter	Production Operation	
	Influent	Effluent[a]
pH, units	5.65 - 6.78	10.00
Suspended solids, mg/l	640	35
Calcium, mg/l	60	60
Lead, mg/l	59	0.77
Zinc, mg/l	72	1.26
Dissolved solids, mg/l	535	450
Cadmium, mg/l	0.45	0.01

[a]Typical clarified effluent - lime treatment

Lead and zinc removals were typically greater than 98 percent at a treatment pH of 10.0-10.5. About 450 mg/l of lime was needed to maintain this pH level. Heavy metal removal was found to be a function of clarifier effluent pH level. Effluent heavy metals concentrations generally increased with the addition of soda ash. Dissolved solids concentrations were slightly reduced through the clarification process. It is speculated that most of this reduction can be attributed to silicate removal. Influent cadmium (0.45 mg/l average) was removed to 0.01 mg/l through clarification. The pilot study also determined that lime softening could consistently reduce influent calcium levels to 35-40 mg/l. However, to achieve optimum metals removal, a pH of 10.0-10.5 was necessary and resulted in an increase in the effluent calcium concentration to about 60 mg/l. Excess calcium present in a recycled water can cause calcium carbonate scale problems under certain conditions. For all runs conducted at elevated pH, the Langelier Index was calculated. A positive index resulted for each run, indicating the potential for scale deposits to form. To eliminate potential scale formation, effluent pH would need to be adjusted to 7.0-7.5. The

study determined that 115 mg/l of 66°Be' sulfuric acid would provide sufficient pH adjustment. An alternative would be to reduce the effluent calcium concentration through addition of soda ash. Soda ash dosages ranging from 50 to 500 mg/l were investigated. The effect of soda ash concentration on clarifier effluent calcium concentration is illustrated in Figure 3. A linear relationship exists. The effluent calcium concentration decreases as soda ash dosage increases. Effluent values as low as 14 mg/l calcium were achieved. Conversely, effluent lead and zinc values increased with increases in soda ash dosage. As effluent calcium is reduced, the wastewater becomes softer and the possibility of scale formation in pumps and piping is reduced. However, a median should be established at a point where the system can be operated successfully at the highest calcium concentration, thereby minimizing the relatively high cost of soda ash treatment.

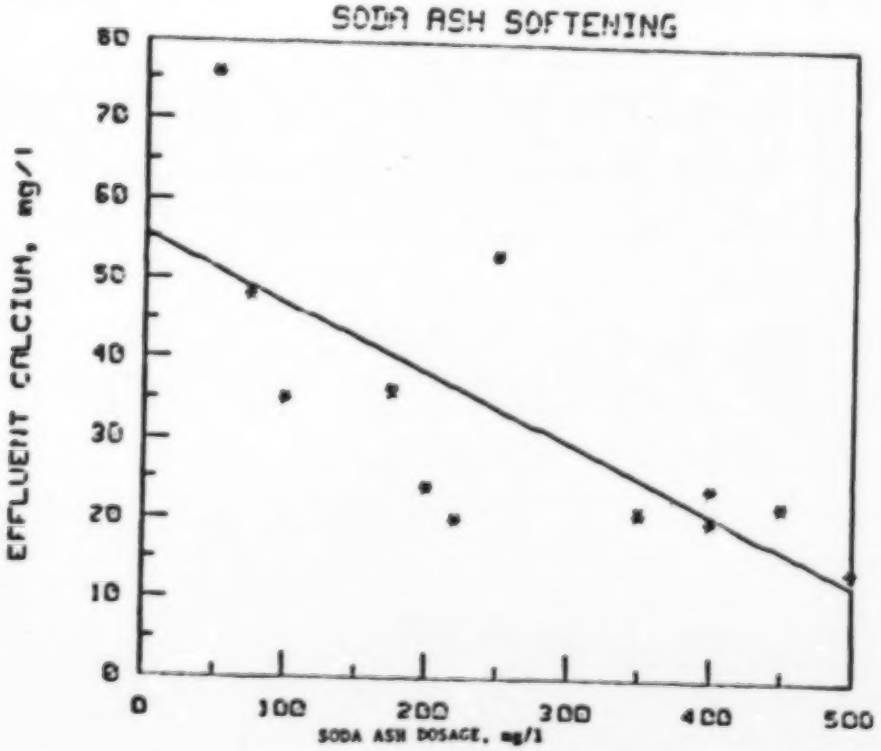

Figure 3. Effluent calcium concentration versus soda ash dosage-clarification testing.

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Two types of polymers were investigated during the study, namely, Magnifloc 1561/1820 and Percol 728. Both types worked well as a coagulant aid. The optimum dosage for Magnifloc 1561/1820 was determined to be 1.5/0.5 mg/l, respectively, while 1.0 mg/l of Percol 728 provided sufficient dosage.

Filtration

Dual media filtration was investigated as a treatment technology for polishing the clarified foundry wastewater. Through the test program, constant rate pressure filtration was evaluated.

Table 3 presents a summary of the filter performance. These performance data were taken from 24-hour composite samples. The pilot filter was essentially a polishing step to remove that portion of suspended solids and turbidity not removed in the clarification process. Suspended solids and turbidity removals averaged approximately 80 and 70 percent, respectively. During the study, it was determined that effluent suspended solids as low as 1 mg/l could be routinely achieved.

TABLE 3. AVERAGE FILTER PERFORMANCE

Parameter	Influent	Effluent
pH	7.0	7.0
Suspended solids, mg/l	35	7
Turbidity, NTU	9.4	3.7
Lead, mg/l	0.77	0.25
Zinc, mg/l	1.26	0.41
Temperature, °C	42	42

Flux rates from 122 to 407 $l/min/m^2$ (3-10 gpm/ft^2) were studied. Optimum solids loading and removal efficiency was achieved at an operating rate

of 326 l/min/m^2 (8 gpm/ft^2). Some surface filtration was observed during testing but it was not significant enough to affect filtration run time. The study predicted that an average run time of about 30 hours would be possible between backwashes. When backwashing would be necessary, a loading of 611 l/m^2 (150 gal/ft^2) would adequately clean the bed. This is equivalent to about 1 percent of incoming flow. This washwater would be returned to the head end of the clarifier for treatment.

Polymer was investigated as a possible filter aid. Testing confirmed that there was no enhanced removal of contaminants and, polymer would not be recommended for full-scale application at this facility. Constant-rate constant-head-pressure filtration would be the recommended method of flow.

COST SUMMARY

A summary of the costs associated with clarification/filtration of the foundry plant wastewater is shown in Table 4. Designs are presented for flows of 379, 1893, and 9463 m^3/day (0.1, 0.5, and 2.5 mgd).

TABLE 4. FOUNDRY PLANT TREATMENT TRAIN COST SUMMARY

Size, m^3 day (mgd)		379 (0.1)	1893 (0.5)	9463 (2.5)
Capital Costs ($)				
Clarification		269,000	377,000	834,000
Filtration		114,000	221,000	736,000
	TOTAL	383,000	598,000	1,570,000
Operating Costs ($/yr)				
Clarification		60,000	108,000	313,000
Filtration		26,000	33,000	59,000
	TOTAL	86,000	141,000	372,000
Operating Costs $/3785 l ($/1000 gal)				
Clarification		1.64	0.59	0.34
Filtration		0.71	0.18	0.06
	TOTAL	2.35	0.77	0.40

The clarification design assumes the use of lime and polymer. If lime/soda ash softening were used instead of lime alone, clarification capital costs would be increased by about 5 percent and operating costs by 10 percent. The design overflow rate selected was 52 $m^3/day/m^2$ (1272 gpd/ft^2). The filtration system design assumes constant-rate pressure filtration. The design flux rate is 326 $l/min/m^2$ (8 gpm/ft^2).

SPACE REQUIREMENT SUMMARY

Table 5 lists the space requirements for various size foundry wastewater treatment systems. The space requirements presented include an allowance for the area between structures, space for interconnecting piping, etc.

TABLE 5. FOUNDRY PLANT TREATMENT TRAIN SPACE REQUIREMENTS

System Capacity, m^3/day (mgd)	379 (0.1)	1893 (0.5)	9463 (2.5)
Space Required, m^2 (ft^2)			
Clarification	90 (970)	163 (1750)	570 (6140)
Filtration	19 (200)	74 (800)	362 (3900)
TOTAL	109 (1170)	237 (2550)	932 (10040)

PRIORITY POLLUTANT TESTING SUMMARY

Two 24-hour priority pollutant sampling periods were conducted during the test program. The periods were scheduled to compare the performance of the lime and lime/soda ash treatment trains in priority pollutant removal. The sampling points for these trains were:

1. Raw wastewater,
2. Neutralized, clarifier effluent, and
3. Filter effluent.

The foundry service water was also included in the priority pollutant screening.

Metals

The priority pollutant metal verification data for the two treatment trains are summarized in Table 6. Examination of this table reveals that both trains were effective in reducing most priority pollutant metals to, or near, the method detection limits. The high concentration of lead in the raw wastewater prevented its reduction to near the detection limit, although approximately 99 percent removal was achieved by both systems. As expected, the clarification step removed the majority of metals present for both treatment trains. The lime treatment system generally achieved slightly higher metal removals than the lime/soda ash system.

TABLE 6. PRIORITY POLLUTANT METALS DATA SUMMARY

Parameter	Raw Wastewater[a]		Clarifier Effluent		Filter Effluent		Service Water
	Lime/Soda Ash	Lime	Lime/Soda Ash	Lime	Lime/Soda Ash	Lime	
Antimony	1010	826	116	75	101	70	
Arsenic	16.6	15.4	<1.5[b]	<1.5	<1.5	<1.5	
Beryllium	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2
Cadmium	338	340	54	20	33	34	<14
Chromium	130	130	<50	<50	<50	<50	<50
Copper	789	940	98	98	136	78	<40
Lead	58,100	60,500	2,380	1,780	600	600	250
Mercury	0.4	0.7	<0.3	<0.3	0.3	<0.3	<0.3
Nickel	67	90	<67	<67	<67	<67	<67
Selenium	8.1	9.3	3.9	1.5	<1.2	3.9	<1.2
Silver	49	39	<25	<25	<25	<25	<25
Thallium	2	3	<1	1	1	2	1

[a] All results in µg/l.

[b] < represents the lower limit of detection for the method and/or instrument.

Organics

The lime and lime/soda ash treatment trains achieved only minor removals of base/neutral extractable compounds. The lime treatment train achieved good removal of phenolic compounds. The raw waste phenol concentration of 5000 ug/l was reduced to 2100 ug/l by clarification. Filtration further reduced phenol to 1900 ug/l. The service water contained less than 50 ug/l. Any phenolic compound removal in the lime/soda ash train occurred in the filtration step. Generally, both trains exhibit relatively low organic priority pollutant removal. Process wastewater from the foundry studied consists of cupola scrubber water, slag quench water, permanent mold cooling water, dust collector water, and heat exchanger blowdown. These sources contribute about 75 percent of the total volume of the stream from which wastewater was withdrawn for this project. The other 25 percent is primarily comprised of plant sanitary wastewater and process wastewater from a plastics molding operation at the plant site.

WATER REUSE/EFFLUENT DISCHARGE

The results of this study have shown that it is feasible to treat the gray iron foundry industry wastewater to a high quality using a treatment train consisting of chemical addition/clarification and filtration.

To minimize foundry plant recirculation system problems, reclaimed water (2):

- Must not form scale on heat exchanger surfaces,
- Must not be corrosive to metal in the cooling system,
- Must not supply nutrients promoting the growth of slime-forming organisms,
- Must not foam excessively, and
- Must not cause the wood in cooling towers to deteriorate.

The recommended water quality criteria for cooling water supplies are presented in Table 7 (3). These data are provided for reference purposes to compare qualitatively with the pilot treatment system results, and are not intended to serve as hard and fast limitations for reusable water quality. It is recognized that the quality of foundry industry reused water which should be maintained varies with the intended purposes (e.g., cooling water of cupola tuyeres [non-contact] requires very clean water, while makeup for other foundry process waters, such as for slag quench, melting furnace scrubbers, etc., need not be so clean).

A summary of the treated foundry wastewater quality after clarification and filtration is also shown in Table 7. Also listed in the table are the plant service water quality and stream discharge standards. In reviewing the table, it is evident that the treated effluent met water reuse guidelines for virtually all parameters except ammonia, aluminum, and calcium which were just slightly above the reuse quality limitations.

The effects of closed loop reuse on buildup of dissolved solids, etc., after several cycles of recirculation, could not be predicted from the pilot scale study. This question is probably best addressed by implementation of the proposed treatment scheme on a full-scale basis under controlled conditions (e.g., elimination of rain water).

The slightly high calcium in the watewater can be reduced through the addition of a small amount of soda ash. The pilot soda ash study was conducted to generate background information for foundries whose wastewater may require further softening in addition to that achieved by lime alone. At the site investigated, it is doubtful that soda ash addition would be necessary. The slightly positive

TABLE 7. COMPARISON OF TREATED FOUNDRY WASTEWATER TO WATER MAKEUP GUIDELINES

Parameter	Typical Treated Clarifier Effluent	Typical Treated Filter Effluent	Plant Service Water	Stream Discharge Standards[a]	Cooling Water Reuse (3)	Comments
Chloride, mg/l	62	62	9		500	
TDS, mg/l	450	447	112		500	
Hardness, mg/l $CaCO_3$	155	150			600	
Alkalinity, mg/l $CaCO_3$	103	103	100		350	
pH, units	7.0	7.0			6.9-9.0	Preferably 6.8-7.2
COD, mg/l	59	56	5	208	75	Preferably below 10
TSS, mg/l	35	7	1	52	100	Preferably below 10
Turbidity, NTU	9.4	3.7			50	Preferably below 10
BOD_5, mg/l					25	Preferably below 5
NH_4, mg/l	4.48	4.65			4	Preferably below 1
PO_4, mg/l	0.01	0.01	0.09		1	
SiO_2, mg/l	9				50	
Al, mg/l	2.5	2.4			0.1	
Fe, mg/l	0.6	0.25	0.14		0.5	
Mn, mg/l	0.25	0.17	0.01		0.5	
Ca, mg/l	60	55	7.3		50	
Mg, mg/l	1.3	1.2	1.6		b	
HCO_3, mg/l					24	
SO_4, mg/l	165	155	16		200	
Oil & grease, mg/l	1	1		26		
Zinc, mg/l	1.26	0.25		2.6		
Lead, mg/l	0.77	0.41		1.32		

[a]Based on an effluent discharge of 454 l/min (120 gpm)
[b]Accepted as received

scaling potential of the treated water can be controlled less expensively through the addition of acid. If total water reuse were implemented, it is possible that clarification treatment could be performed at a slightly lower pH (say 9.0-9.5). This would increase effluent metals concentrations but would not adversely affect reuse quality. Reduced pH would also reduce lime costs, effluent calcium, and acid requirements. Filtration of the clarified effluent would be a recommended post-treatment adjunct for polishing purposes and improved reliability.

REFERENCES

1. Development Document for Effulent Limitations Guidelines and Standards for the Metal Molding and Casting (Foundries) Point Source Category, EPA-440/1-82-070, U.S. EPA, Effluent Guidelines Division, Washington, DC, November 1982.

2. Guidelines for Water Reuse, EPA-600/8-80-036, U.S. EPA, Municipal Environmental Research Laboratory, Cincinnati, OH, August 1980.

3. National Academy of Sciences - National Academy of Engineering, Water Quality Criteria 1972: A Report of the Committee on Water Quality Criteria, EPA-R3-73-033, U.S. Environmental Protection Agency, Washington, DC, 1973, 594 pp.

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